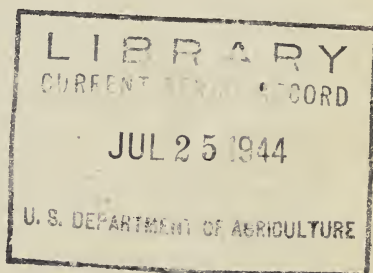


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PRINCIPLES OF NUTRITION AND NUTRITIVE VALUE OF FOOD



**U. S. DEPARTMENT OF AGRICULTURE
Miscellaneous Publication No. 546**

Foreword

This publication tells the main facts about human nutrition and the various substances in foods that are needed to nourish our bodies.

It is published at a time when, for two reasons, more people than ever before are interested in nutrition. First, although the science of nutrition is young, it has built up a large amount of knowledge that has proved to be vital to our well-being. Second, making the best use of foods to maintain health is especially important in wartime, and many people now know that this cannot be done without relying on the science of nutrition. This publication will help them. It is written by a man whose knowledge and judgment are based on a lifetime spent in nutrition research.

The publication marks an important anniversary in the science of nutrition. W. O. Atwater, one of the pioneers in this science, was born 100 years ago, in 1844. Fifty years ago, in 1894, Congress first recognized human nutrition as a matter of public concern by appropriating funds for work in this field. The work was directed by Dr. Atwater, who was the first head of the Office of Experiment Stations in the United States Department of Agriculture. Thus, Dr. Atwater was responsible for starting the cooperation between the States and the Department which has contributed so much to modern knowledge of nutrition.

The author of this publication was at one time Dr. Atwater's assistant. As a tribute to Dr. Atwater, the publication has been given the same title as that of Farmers' Bulletin No. 142, Principles of Nutrition and Nutritive Value of Food, which was prepared by Dr. Atwater in 1901 and has long been out of print.

E. C. AUCHTER,
Administrator of Agricultural Research.

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Principles of Nutrition and Nutritive Value of Food

by

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NUTRITION has at least two meanings. It may mean bodily condition as expressed more formally by the term "nutritional status" of the body. It may also mean supplying the body with nutrients—with the things which nourish it.

The General Functions of Food

Food nourishes the body in three main ways. First, it furnishes the fuel to yield energy, which appears as warmth and work; second, it supplies the structural materials for the growth and upkeep of body tissues; and third, it provides substances which keep bodily conditions right, so that life processes proceed normally.

A Grouping of Nutrients

Something like 40 different nutrients (elements or substances in the chemical sense) must certainly be furnished by food. Fortunately, however, one can have a sound and serviceable knowledge of nutrition and of the nutritive values of foods without studying the chemical and physiological technicalities of forty-odd nutrients; and it is as a non-technical introduction that this publication is written.

A convenient starting point is a fourfold grouping of nutrients into: (1) Those that burn as fuel in the body and so yield energy; (2) the proteins and their amino acids; (3) the mineral elements; and (4) the vitamins.

This fourfold arrangement follows the order in which the present-day knowledge of nutrition has actually been built up by research. There have been four successive, though overlapping, periods or steps in the building of our present structure of nutritional knowledge. It may also be useful to say that any true view of nutrition must see it as standing foursquare upon equal recognition of its energy, protein, mineral, and vitamin aspects.

This way of speaking also helps to dispel any remaining traces of a tendency of some to talk as if there were rival views—a calorie theory versus a vitamin theory—of nutrition, which is as absurd as if one should speak of the gasoline theory versus the ignition-spark theory of running an automobile.

¹ On leave of absence from Columbia University, 1943-44.

The body is much more than a machine, and a mechanical analogy gives us only a very partial picture. But by those who feel it helpful, the fuel foodstuffs may be likened to the gasoline for the automobile; the proteins and some of the minerals, to the materials of which the motor is made; other minerals, to its lubricants; and the vitamins to the ignition sparks, whose own energy is insignificant, but which perform the indispensable function of keeping the motor running in an orderly way. In sketching the principles of nutrition we may best think of them primarily as aspects of the life process—or of the complex of processes which life involves.

The Energy Aspect of Nutrition

Every act and moment of life involves expenditure of energy. We are fully aware of this when we do work upon something outside of the body itself—external muscular work. Also, there is always a very significant amount of internal work, such as breathing, heart action, and muscle tension, which varies in degree but never ceases throughout life.

When, beginning in 1894, Congress made a small appropriation for investigations in human nutrition, about one-half of it was invested in very exact researches upon this energy aspect while the remainder was devoted chiefly to widespread dietary studies in different parts of the United States.

Professors W. O. Atwater, E. B. Rosa, and F. G. Benedict developed in the basement of the chemical laboratory of Wesleyan University, at Middletown, Conn., a respiration calorimeter for the study of the energy relations of nutrition to the human body. At the same time Atwater with other coworkers, devised an improved type of bomb calorimeter for the determination of the fuel values of foods by burning them in compressed oxygen.

Food as Source of Energy

As the result of years of most painstaking research it was found: (1) That with the bomb calorimeter the energy or fuel values of foods can be measured with great precision; and (2) that men living for periods of several days in the respiration calorimeter give off as warmth and work an amount of energy almost exactly equal to that computed from the fuel values of the nutrients burned in their bodies as shown by chemical analyses of what enters and what leaves the body.

Our food is, therefore, the source of practically all the energy used in our life processes.

Although, as a result of the development of newer methods, the actual measurements made in studying the energy metabolism²—energy exchange in the body—are now only rarely direct measurements of heat, yet the results continue to be expressed in terms of calories.³

² By literal derivation, the word "metabolism" means simply change or exchange. In statements about nutrition, it means the character or amount (or both) of a given kind of change or exchange that goes on in the body, e. g., the metabolism of energy or of a given kind of material.

³ The formal definition of the calorie (kilogram-calorie or greater calorie) is the amount of heat required to raise the temperature of 1 kilogram of water 1° C. This is practically the same as to raise 1 pound or pint of water 4° F. There is a smaller calorie, which is one-thousandth of this, but it is seldom used in discussions of nutrition or food values.

So firmly fixed is this usage that it does not seem likely to change. However, the body is not a heat engine. The heat generated in the body is not the source but rather the end product of the work the body does. And even though we count the fuel value of foodstuffs in calories and speak of these foodstuffs as burned (oxidized) in the body as fuel, yet the fuel value of the foodstuff becomes working energy in the body, not as it would in a heat engine but in some more direct (and usually more efficient) way. Instead of the heat-engine sequence of fuel value into heat into work, the sequence in the body is fuel value into work into heat.

Amounts of Food Energy Needed

Under any conditions of living that we would consider even reasonably comfortable, the body is warmer than its surroundings and is constantly giving off heat to them; yet relatively little fuel is being burned in the body for the purpose of maintaining its temperature. Enough heat for this purpose usually results as a byproduct and end product of activities involved in life processes which would be going on in the body anyway.

Thus, while the body doubtless often burns a little of the fuel foodstuffs to meet the needs of keeping warm, this is rarely more than a minor factor. In the main, the body's expenditures of energy are determined by its internal and external activities.

A fact easy to remember, and helpful in grasping the energy relationships of bodily needs and of food values, is that an average-sized man sitting still spends just about 100 calories of energy per hour.

During the thorough relaxation of restful sleep, the rate is usually about 65 calories an hour; and rates between 65 and 100 calories an hour are observed when the man lies quietly and comfortably while awake. What is termed basal metabolism is that observed under these latter conditions with the further proviso that no food be eaten during the preceding 12 or 14 hours. Taking food, however, usually influences the body's expenditure of energy much less than does muscular exercise.

For instance, if a normal, average-sized man lived entirely in bed or in an easy chair, taking just enough food to maintain his body weight, he would require and expend about 2,000 calories a day; and if he went a day without food his energy expenditure would be decreased only about one-tenth. On the other hand, he might easily double the day's energy output by 8 hours' use of his large muscles.

In health, one rarely spends a 24-hour day without some muscular exercise. The Recommended Dietary Allowances of the National Research Council⁴ (often called the "yardstick of good nutrition") provides 2,500 calories a day for a sedentary, 3,000 for a moderately active, and 4,500 for a very active man. For women (estimated to average four-fifths of the body weight of men) the corresponding allowances are: Sedentary, 2,100; moderately active, 2,500; very active, 3,000 calories a day.

⁴ NATIONAL RESEARCH COUNCIL, FOOD AND NUTRITION BOARD. RECOMMENDED DIETARY ALLOWANCES. Reprint and Cir. Ser. 115, 6 pp. 1943. Washington, D. C.

Healthy children should be active whether their parents are or not. So the yardstick allows them total food calories per day as follows:

Sex-age group:¹

Children:	Calories per day
Under 1 year ² -----	100 per kilogram—(2.2 pounds).
1-3 years-----	1,200 (total).
4-6 years-----	1,600 (total).
7-9 years-----	2,000 (total).
10-12 years-----	2,500 (total).
Girls:	
13-15 years-----	2,800 (total).
16-20 years-----	2,400 (total).
Boys:	
13-15 years-----	3,200 (total).
16-20 years-----	3,800 (total).

¹ Allowances are based on need for the middle year in each group (as 2, 5, 8, etc.) and for moderate activity.

² Needs of infants increase from month to month. The amounts given are for approximately 6-8 months.

The More Abundant Nutrients in Foods

The more abundant constituents of foods which are burned (oxidized) in the body are carbohydrates, fats, and proteins. Table 1 shows the percentages of these, and the energy values, in some typical foods.

In milk—the one article whose sole place in nature is to serve as food—the presence of these three more abundant kinds of organic constituents is easily demonstrated. Thus, if a bottle of natural milk

TABLE 1.—*Protein, fat, carbohydrate, and energy values of 1 pound of some typical foods*

Food	Protein	Fat	Carbo- hydrate	Energy value
	Grams	Grams	Grams	Calories
Apples, fresh raw-----	1	2	59	260
Apricots, dried-----	24	2	303	1,325
Bananas-----	4	.5	70	300
Beans, dried-----	100	7	282	1,590
Beans, snap or string-----	10	1	31	170
Beef, round steak-----	78	54	0	800
Bread, white-----	39	9	237	1,185
Bread, whole-wheat-----	41	14	224	1,185
Broccoli-----	7	.5	11	75
Butter-----	3	367	2	3,325
Cabbage-----	4	.5	18	90
Cantaloup-----	1	.5	10	50
Carrots-----	5	1	37	180
Cheese, Cheddar type-----	108	146	8	1,785
Codfish-----	52	1	0	220
Eggs-----	52	46	3	635
Kale-----	11	2	21	145
Milk-----	16	18	22	310
Oranges-----	3	.5	37	165
Peas, fresh green-----	14	1	36	210
Pork chops-----	60	91	0	1,060
Potatoes-----	8	.5	73	325
Sweetpotatoes-----	7	3	109	490
Tomatoes-----	4	1	18	100

is simply left standing quietly, a layer of cream forms at the top, owing to the rising of the fat globules contained in milk. (If desired, milk may be so treated mechanically as to break up the natural globules of fat into smaller ones which do not rise readily. Milk which has been so treated does not show a cream layer but remains apparently homogeneous on standing and is commonly called homogenized milk.)

Whether or not the cream has been removed, when milk is left to sour or is curdled by adding acid or rennet, the appearance of the curd shows the presence of something which had not previously been visible, but which plays the chief part in the making of cheese. This curd is chiefly due to the presence in milk of a typical protein (casein). If the whey is separated from the curd, concentrated by evaporation, and then allowed to cool under favorable conditions, milk sugar (lactose) gradually crystallizes out.

Milk sugar, cane (or beet) sugar, corn sugar, and starches are typical carbohydrates. Natural milk has about seven or eight times as much water as carbohydrate, fat, and protein combined, so these substances are far too wet to burn under simple application of a flame; but *dried* milk burns very much as does dry wood. The carbohydrates, fats, and proteins all burn away and an ash containing several nutritionally important mineral elements is left. Thus, it is seen that milk contains organic matter (fat, protein, and carbohydrate), as well as water and mineral matter. It also contains vitamins, but the amounts of these are too small to be seen in such simple ways as are proteins, fats, and carbohydrates.

Proteins, fats, and carbohydrates occur in many other foods—one or more of them in almost everything we call food.

In wheat flour the typical carbohydrate, starch, predominates. The amount of fat is invisibly small. There are several proteins in wheat flour and when water is kneaded into the flour two of the proteins unite to form gluten, upon which the bread-making properties depend.

In meat, distinct layers of nearly pure fat can often be seen. The lean portions of meat consist chiefly of proteins with about three times their weight of water and about 1 percent of a mixture of salts.

Amounts of Energy Furnished by Foods

The average energy values to the body of the pure, dry, fuel food-stuffs are as follows:

Nutrient :	Calories per gram ¹	Calories per pound
Carbohydrates.....	4	1,814
Fats.....	9	4,082
Proteins.....	4	1,814

¹ 28.3 grams equal 1 ounce; 453.6 grams equal 1 pound.

One hundred-calorie portions of foods are sometimes used as means of making familiar energy values or of building dietaries in terms of these convenient units. The amounts of some typical foods needed to furnish 100 calories are as follows:

Butter (nearly pure fat), about $\frac{1}{2}$ ounce—a generous pat.

Bread, about $1\frac{1}{4}$ ounces—a thick slice, or 2 thin ones.

Milk, about 5 ounces— $\frac{2}{3}$ of a full-sized glass or cup.

Potato, 5 ounces—1 fair-sized potato.

Apple, 7 ounces—1 good-sized apple.

When we recall that 100 calories is also the approximate amount of energy spent by an average man sitting still for an hour, this visualizing of 100-calorie portions of foods helps us to grasp the quantitative relationships of energy values of foods and energy needs of nutrition.

The "share system," largely used by the late Dr. Mary S. Rose in teaching dietetics, and fully set forth by Dr. Clara M. Taylor in her *Food Values in Shares and Weights*,⁵ also uses 100-calorie portions of foods as a starting point for comparisons and calculations.

Food Calories and the Control of Body Weight

While it is true that a tendency to fatness may "run in the family," and that "the glands may have something to do with it," yet it is also true that too much fat in the body must inevitably mean that there has been too high a food-calorie intake for that person's rate of expenditure of energy.

Conversely, an undue thinness means that the food-calorie intake has been unduly low.

For people having ample food at their disposal, the principle is simple: One may either count the calories or watch the body weight, and eat just liberally enough to have the body weight one wants. Normally the best degree of fatness to maintain is about that which the experience of other people has shown to give the best results in the long run. Such long-time experience has been carefully studied and concisely summarized by life-insurance companies and the United States Public Health Service. Their extensive studies show that the average weight for a given height continues to increase up till middle age, and that the most advantageous degree of fatness—relation of weight to height—is that which corresponds to the average found at the age of 30. This relation of weight to height is shown in table 2.

TABLE 2.—*Weight for height at the age of 30 years*¹

Height	Women	Men	Height	Women	Men
	<i>Pounds</i>	<i>Pounds</i>		<i>Pounds</i>	<i>Pounds</i>
4 feet 10 inches-----	116	-----	5 feet 8 inches-----	146	152
4 feet 11 inches-----	118	-----	5 feet 9 inches-----	150	156
5 feet-----	120	126	5 feet 10 inches-----	154	161
5 feet 1 inch-----	122	128	5 feet 11 inches-----	157	166
5 feet 2 inches-----	124	130	6 feet-----	161	172
5 feet 3 inches-----	127	133	6 feet 1 inch-----	-----	178
5 feet 4 inches-----	131	137	6 feet 2 inches-----	-----	184
5 feet 5 inches-----	134	140	6 feet 3 inches-----	-----	190
5 feet 6 inches-----	138	144	6 feet 4 inches-----	-----	196
5 feet 7 inches-----	142	148			

¹ In this table, the height includes ordinary shoe heels and the weight includes ordinary indoor clothing.

Below the age of 30 a majority of our people tend to be underweight and would do well to build themselves up to the weight-for-height shown in this table. On the other hand, as they enter middle age most people should be on guard that they do not let their body weight run too much above the standard for their height as indicated in table 2.

⁵ TAYLOR, C. M. *FOOD VALUES IN SHARES AND WEIGHTS*. 92 pp., illus. 1942.

Of course any such simple standard can only be an indication, not a rigid rule. For obviously at the same degree of actual fatness the person of broad, stocky build weighs more, and the slenderly built person weighs less, than the general average weight-for-height at any given age.

Proteins and their Amino Acids in Foods and Nutrition

The word "protein" was coined about a century ago, from the Greek verb "to take the first place," and was given as a name to what was supposed to be the fundamental substance of body tissues. While subsequent chemical research shows that there is no one such substance, the word (with its inherent claim to primacy of consideration) has continued steadily in use and doubtless has a greater force of tradition behind it than does any other of our everyday nutritional terms.

The word is used in both the collective-singular and plural forms to designate any or all, as the case may be, of those substances occurring in the protoplasm of both plant and animal tissues which resemble each other (1) in containing a relatively large amount (averaging about 16 percent) of the chemical element *nitrogen*, and (2) in being complex in chemical structure but resolvable in the digestive process, and by certain laboratory methods, into the less complex substances known as *amino acids*. By mechanical analogy the proteins are prominent in the body's tissue structure, in which the amino acids are the smaller units corresponding to building blocks or building stones.

A typical protein molecule is so large as to contain hundreds of amino-acid building blocks; but usually these latter are of only about 20 kinds. Moreover, of the twenty-odd kinds of amino acids found in body tissues only about half need necessarily be supplied by the food. For, with these indispensable or nutritionally essential amino acids abundantly furnished by the food, the body can make for itself the other amino acids which are regularly found as building stones in its tissue structure.

Another analogy compares the twenty-odd kinds of amino acids to as many kinds of beads, and the complex protein molecules to the elaborate beadwork designs which can be constructed first by different arrangements of beads on their strings and then further by weaving these different strings in differently patterned designs.

At the same time that Atwater and Benedict were bringing the development of the energy aspects of nutrition into its modern status as an exact science, T. B. Osborne was studying the chemistry of food proteins in the Connecticut Agricultural Experiment Station at New Haven. For about a two-decade period overlapping the turn of the century, he devoted himself to the extraction of pure proteins from natural food materials and the chemical analysis of the individual food proteins he thus isolated. In 1907 he concluded a report upon the proteins of wheat⁶ by pointing out that these proteins differed so much in the quantitative proportions of some of the amino acids they

⁶ OSBORNE, T. B. THE PROTEINS OF THE WHEAT KERNEL. 119 pp. 1907. (Carnegie Institute of Washington.)

contained as to challenge strongly the then-prevalent assumption that such proteins were all of the same nutritive value.

F. G. Hopkins, of Cambridge University, England, was independently raising essentially the same question at the same time through his studies of the nutritional importance of individual amino acids such as tryptophane which he found to be unevenly distributed among food proteins.

Also at about this time, others were studying, more critically than had been done before, the question: How much protein is needed in human nutrition? It was found by many workers, that the requirements of normal nutrition can be met with much less protein than European and American writers were and are accustomed to assign to "good" diets.

How Much Protein Is Best?

How much food protein it would be best for each of us to eat in the interest of nutritional well-being is a question which does not admit of a simple, conclusive answer. Several circumstances combine to delay the prompt reaching of a real consensus of expert opinion on this point. Relatively long-time researches into the more permanent effects of different levels of protein feeding may still be needed in order clearly to distinguish science from tradition in the interpretation of clinical experience. Also, the fact that different food proteins contain different proportions of the individual nutritionally essential amino acids inevitably means that what has hitherto been called the protein problem must be a whole group of amino acid problems. In this latter field of research current work is making distinct scientific advances.

The researches of many workers, prominent among whom are W. C. Rose, of the University of Illinois, H. B. Lewis, of the University of Michigan, and D. B. Jones, of the United States Department of Agriculture, have greatly extended our knowledge of the fate and functions of individual amino acids in our bodies and their quantitative distribution in our foods. With the aid of this knowledge investigators are turning renewed attention to such questions as the extent to which we can depend upon foods furnished directly by the land, and how supplementing these cheaper forms of protein by the more costly proteins of animal origin can be managed with maximum economy and efficiency.

Different Types of Food as Sources of Protein

Even after a generation of relative neglect of bread as a food, bread-stuffs and cereals still furnish over one-third of the total protein of our typical diets; and the enrichment now current enhances the actual value of, and the feeling of confidence in, the ordinary white bread of commerce. The nutritive value or nutritional efficiency of the proteins of our grain products is therefore a problem of very real importance.

That the proteins of whole wheat are of much higher nutritive value than those of white flour has been conclusively shown by several independent experiments. Yet in experiments at Columbia University

with white bread or corn meal or oatmeal furnishing nine-tenths, and milk one-tenth of the protein of the diet, men and women maintained protein equilibrium and full health and efficiency when receiving about half as much protein as the National Research Council's yardstick provides.⁷

Osborne and Mendel found that the proteins of whole wheat are in themselves sufficient for all the protein requirements of normal growth and also that good growth was supported by diets in which two-thirds of the protein was from white flour and one-third from meat, eggs, or milk.

American dietaries have usually been rich in protein; and about half the protein has been of animal origin.

Several of the legumes, including soybeans, peanuts, and our ordinary garden or field peas, contain proteins very similar chemically and nutritionally to those of meat and well qualified for the position of main dish at dinner. Ordinary baked beans when eaten as sole protein food are not quite so efficient in nutrition, but become so when supplemented with the proteins of wheat as in the familiar Boston baked beans and brown bread.

The question how large a place it is nutritionally wise to give to legume proteins in diets which contain relatively small amounts of animal protein, as may be the case when the food supply is restricted by war, by limited economic resources, or by other conditions, is now a subject of careful experimental research in the United States Department of Agriculture.

Enough has already been learned to show that the old habit of specifying some fixed proportion of animal protein in setting a protein standard for dietaries or food supplies is now superfluous.

Amounts of Protein Recommended

The amounts of protein recommended by the National Research Council are as follows:

For children under 1 year of age, 3 to 4 grams per kilogram of body weight per day; 1 to 3 years, 40 grams protein a day; 4 to 6 years, 50 grams; 7 to 9 years, 60 grams; 10 to 12 years, 70 grams; boys 13 to 15, 85 grams; boys 16 to 20, 100 grams; men, regardless of the degree of activity, 70 grams; girls 13 to 15, 80 grams; girls 16 to 20, 75 grams; women, regardless of muscular or mental activity, 60 grams, rising to 85 grams in pregnancy, and to 100 grams in lactation.

We Have Comfortable Margins Above Actual Needs

Taking account of the relative numbers of people of these different descriptions in the population of the United States, our daily yardstick allowance becomes 65 grams of protein for each person.

Prof. H. B. Lewis,⁸ of the University of Michigan, in a recent review in the *Journal of the American Medical Association* emphasizes the fact that the yardstick allowances are placed well above the average of actual need—perhaps from half as much again to twice as much. Even under wartime conditions, the actual food supply of the United States, after deducting the large quantities of food which are being

⁷ See footnote 4, p. 6.

⁸ LEWIS, H. B. PROTEINS IN NUTRITION. *Amer. Med. Assoc. Jour.* 129: 198-204. 1942.

exported or set aside for our armed forces and for lend-lease, at last accounts was still sufficient to provide 93 grams of protein a day for every person in our civilian population.

Thus, while the assignment of impressive amounts of high-protein foods to our Army, Navy, and allies has tended to make us conscious of a protein problem, the situation is still one in which we need to make only moderate use of scientific knowledge in order to continue to have a safe margin of average consumption above actual nutritional need. The typical foods in table 1 show how the choice of foods influences the protein content of the diet. Tradition still leads many people to speak as if the proteins carried all nutritional responsibilities beyond those of calories; but the newer knowledge of nutrition shows that mineral elements and vitamins are as important as calories and proteins. As previously mentioned, our nutritional concepts should "stand foursquare" upon these four aspects of nutritive needs and values.

Mineral Elements in Foods and Nutrition

The body's framework or skeletal system of bones and teeth owes its strength and normal form to the fact of its being well mineralized. Smaller amounts of much more soluble mineral salts are constantly present in the soft tissues and fluids of the body. These facts had long been known, but only with the development of twentieth-century science could they be fully appreciated.

It was almost precisely at the turn of the century that Atwater made provision for the study of such mineral elements as calcium, phosphorus, sulfur, and iron as part of the investigation of human nutrition that he was directing. Simultaneously students of the "pure" physical chemistry of physiology were beginning to study the soluble mineral salts as the things that "put life into" the proteins of the body tissues and fluids.

In our ordinary way of speaking, the chemical elements are the ultimate constituents of which the physical world (living and nonliving) is built. Chemists agree in speaking of 92 such elements as things of quite fundamental and ultimate importance to our understanding of the world in which we live; and it may at first seem strange that investigators are not yet entirely agreed as to how many of these elements are essential to our nutrition. The reason for this, however, is not difficult to understand and should not be disconcerting. It is simply that there are limits to the delicacy of all laboratory methods; and if the amount of a given chemical element in the body is so small as to be practically at the limit of the chemist's ability to work with it, a doubt may well remain as to whether its presence is essential to us or only incidental to its presence in our surroundings. For, a trace of any element that occurs in nature may be accidentally present in the food we eat, the water we drink, or the dust of the air we breathe.

In such a case, then, we may not be entirely certain whether the trace element is nutritionally essential or not; yet we may be scientifically justified in the belief that we can safely ignore the element in our dietary calculations because of the evidence that, if any of it is essential to our nutrition, the amount thus needed is so small as to be provided, as just explained, without any planning on our part.

Of the mineral elements concerned in our nutrition all but four can thus be left to chance. These four are calcium, phosphorus, iron, and iodine.

Calcium and Phosphorus

Calcium and phosphorus are the outstanding elements of the mineral matter of bones and teeth, while the soft tissues of the body contain considerable amounts of phosphorus but only very small amounts of calcium.

During infancy, when there is a rapid growth of muscles and other soft tissues at the same time as the development of the bones, the body's demand for phosphorus may outrun its supply to a greater extent than is the case with calcium. If this happens there may be a period of low-phosphorus rickets. But now that the prevention of rickets is generally understood, and with such food supplies as are commonly used in nearly all parts of the world, the shortages of bone-building material that occur in human nutrition commonly mean a need for more calcium rather than for more phosphorus. In fact we may usually consider that dietaries which are adequate in all other respects can be trusted to contain adequate amounts of phosphorus without any special planning on our part.

Iron

The same assumption now seems generally safe as to the adequacy of our food iron for our normal nutritional needs. In the United States and some other countries this is only just now becoming true with the general use of bread which is "enriched" and cereals which are "restored" by addition of sufficient iron to bring them to about the same iron content as the natural grain from which the flour or breakfast cereal is made. With respect to our supply of food iron, we are thus tardily bringing ourselves abreast of those who have maintained the use of whole-grain products as their basic bread or cereal supply.

With natural whole-grain or enriched or restored breadstuffs and cereals occupying their full normal place in our food habits and with our dietaries containing the other foods which we generally use, acceptable food supplies will usually furnish enough iron without special planning. There may be some individuals who need more; but they should be readily detected by a slight tendency to anemia and should be treated as a medical rather than a normal nutritional responsibility.

Iodine

Iodine, which enters the body almost entirely as iodide,⁹ is an even more special case. For while iodine is essential to our nutrition we usually get it more largely from drinking water and table salt than from our foods. Sea salt, rock salts, and the brines of salt wells

⁹ Table salt is sodium chloride. Sea salt is chiefly this same sodium chloride with a little of the corresponding iodine salt, sodium iodide, and small amounts of several other elements.

contain small, but physiologically important, amounts of iodide along with their much larger amounts of chloride.

The refined salt from any of these sources is essentially pure sodium chloride. Hence this purification results in a nearly complete loss of the iodide which was naturally present. If, then, the soils and waters of the region are of low iodide content, iodine deficiencies may occur. Such deficiencies are now guarded against by the use of iodized salt. This is not to be considered as medicated, but rather as restored to something like the iodide content of natural salt deposits or the natural brines of salt wells, the kinds of common salt that a natural food-and-drink supply provides.

Practical Importance of Calcium

Calcium is one of the two nutrients in which American dietaries or food supplies most often fall below the recommendations of the Food and Nutrition Board of the National Research Council.

Calcium deficiencies in nutrition are much more frequent than physicians commonly realize, because there is no good way of detecting them. In fact, a condition which nutrition research has now shown to be one of shortage, as viewed in the light of the full life history, is still commonly counted as within the range of the normal. In the light of present knowledge of lifetime relationships it is now apparent that we are all born calcium-poor. That is, the human body at birth has not only a much smaller amount but also a much smaller percentage of calcium than the normal fully developed body contains.

Undoubtedly the characteristic of being born with soft flexible bones has had survival value for our species; for the giving of birth is thereby rendered easier and safer. Once safely born, however, it is doubtless to the advantage of the body that its calcium content catch up with the other aspects of its development as promptly as may be.

In order to develop normally, the child needs not only to increase the amount, but also to increase the percentage, of calcium in his body, at the same time that the body weight is increasing rapidly. This means an accentuated need for calcium as compared with the need for other body-building materials.

Without a relatively high calcium intake, the body must remain calcium-poor. Sometimes, it always remains so. People may thus go through life with calcium-poor bodies, partly because there is no method of directly diagnosing this condition. It can, however, be studied by research methods.

Calcium Often the Limiting Factor in Bodily Development

Large numbers of experiments have now been made, in which the amounts of calcium entering and leaving the body have been accurately determined by chemical analysis of the food (plus drinking water) and of the excretions.

These are called calcium-balance experiments. They show that in children of all ages the rate at which the body can build the needed calcium into its structure depends largely upon the daily amount received in food and drink. Studies by several investigators have shown undoubtedly better development in the children receiving and storing calcium in the more liberal amounts.

By the use of experimental animals, whose bodies can be analyzed for calcium at different ages while duplicates are continued on their respective diets throughout their natural lives, it has been possible to confirm the finding that increasingly liberal amounts of calcium in the food are increasingly beneficial both to the development of the young and to better health and longer life in the adult.

Amounts of Calcium Recommended

Calcium is more generally appreciated for children than for men and women. The recommended allowances of the National Research Council, for example, provide from 1.0 to 1.4 grams of calcium per day for children, but only 0.8 gram for men, or for women except during pregnancy and lactation. Doubtless it is better to allow at least 1 gram a day for every person.

Notwithstanding the fact that, for a large proportion of the population, the National Research Council's standards¹⁰ provide less safety margin for calcium than for other nutrients, shortage of calcium in American dietaries (as judged by these standards) is of outstanding frequency.

Very recently, therefore, animal experimentation has been carried still further and the results show with statistical convincingness that, even up to levels more than twice those of minimal adequacy, increasing calcium content of food gives increasing benefit throughout the life history of the individual, and adds to the stamina of the following generation.

Inasmuch as 99 percent or more of the calcium in the body is in the form of relatively insoluble bone mineral, the question naturally arises how this can have such an important influence upon individual and family well-being.

An interesting explanation (which of course may not be the only one) is found in the fact that when food calcium is more liberal there results a better development of the internal structure of the bones. This is particularly true within the porous ends of long bones, where it means a greatly increased surface of bone mineral in contact with the circulating blood, and therefore a much more prompt and effective restoration of the blood calcium to full normal concentration after all the many small wastages that occur in everyday life as well as under various conditions of extra strain.

Even though the fluctuations of blood calcium concentration are small from the viewpoint of our ability to measure them, yet the more quickly and completely the blood recovers from every decline in its calcium content the better the body maintains its highest degree of health and efficiency.

¹⁰ See footnote 4, p. 6.

Thus it is very important to the welfare of every country that its people get a good calcium supply from their food and drinking water. It is said that, in some regions, the drinking of turbid water provides an important part of the needed calcium; but the amount furnished by most drinking water is only a small fraction of what we need. Bones are utilized as food in some countries to an important, but in other countries to only an insignificant, extent. In these latter countries milk and green leaf vegetables are the chief sources of dietary calcium.

Inasmuch as many people still lack adequate appreciation of milk and of green leaves as food, some study of the calcium content of these and other foods may be helpful to the planning of dietaries, or to the forming of such individual food habits as will ensure the liberal amounts of food calcium that are now known to be important to lifetime and family health.

Table 3 shows the relative richness in calcium of typical foods as bought and sold—some wet and some dry. Note that milk, which is seven-eighths water, and kale, with its still higher water content, both contain, in this natural wet state, more calcium pound for pound than do typical fruits, root vegetables, meats, or breadstuffs. It was because of the dietary importance of milk and green leaf vegetables as sources of calcium and vitamin A (see p. 28) that McCollum coined for them the term "protective foods." Headed cabbage, however, is not fully a green leaf food and has only about the same calcium content as carrots.

TABLE 3.—*Approximate average calcium content of the edible portion of some typical foods*

Food	Calcium (milligrams ¹ per pound)	Food	Calcium (milligrams ¹ per pound)
Apples (4 average-sized)-----	24	Carrots-----	150
Bananas (4 good-sized)-----	24	Cheese, Cheddar type-----	3,960
Beef, lean-----	45	Eggs (8 or 9)-----	218
Bread, white-----	² 200	Kale-----	650
Bread, whole-wheat-----	² 250	Milk (scant pint)-----	535
Broccoli (4 cups, cooked)-----	² 400	Potatoes (4 good-sized)-----	50
Butter-----	70	Sweetpotatoes (4 good-sized)-	100
Cabbage, headed-----	150	Tomatoes-----	50

¹ A milligram is $\frac{1}{1000}$ of a gram. So the previously mentioned calcium requirement of 0.8 gram is 800 milligrams a day.

² Varies with ingredients used in bread making.

³ Varies with the proportion of leaves eaten.

The Vitamins

The vitamins have been so much before the public that a formal introduction to the vitamin family now seems superfluous. Moreover, we now see that it was little more than a historical accident that these substances came to be called by a group name, for they are not a natural or closely related group. Each is to be judged and, if worth while, studied on its own merits as a nutrient and not because it has the word vitamin in its name.

In fact the tendency of science is to give each of these substances a more distinctive and independent name when we feel sufficiently acquainted with its chemical nature. To the extent that we use the alphabetical sequence here, we do it merely as a matter of convenience.

Vitamin A

Vitamin A itself is a colorless fat-soluble substance occurring to an important extent in milk (and such of its products as contain its fat), eggs, fish-liver oils, and the livers of other animals. It is formed from precursors (antecedent substances, provitamins) which are products of plant life.

There are at least four of these precursors or provitamins A: Three carotenes and a related substance called cryptoxanthin. Often these are called by the group name carotenoids, or for convenience the simple word carotene is sometimes used as standing for any or all of them that may be present.

These are orange-yellow substances formed in green plants where to a large extent they remain in the leaves and are hidden by the intense greenness of the chlorophyll present. But some plants such as carrots, sweetpotatoes, and pumpkins transfer a part of their carotene to their roots or fruits and so become yellow vegetables. Hence, leafy, green, and yellow vegetables are often grouped together because of their vitamin A value.

(Note that the phrase "vitamin A value" is accurate and convenient as covering this contribution to our nutritional need whether the food furnishes it as preformed vitamin A or as carotene or as a mixture of these.)

When the dietary is deficient in vitamin A value, the body may be unfavorably affected in any one, or any combination, of several ways. The first effect to be definitely recognized was retardation of growth, and this vitamin thus came to be thought of as especially a requirement of the young; but we now know that it is highly essential at all ages.

It is easy to draw up a long list (or to crowd the assigned space on a vitamin chart) in attempting to summarize the bodily injuries which may result from a shortage of vitamin A. This is partly because it performs more than one function, and partly because at least one of its functions extends to all parts of the body.

Thus, vitamin A is essential to the maintenance of the normal cellular structure and function of the body's external and internal surface membranes. A certain dryness of the skin may be, for those who are trained to recognize it, perhaps the most usual first sign of a shortage of vitamin A; while what a beginner most often recognizes as a characteristic sign in an experimental animal is a related abnormality in the mucous membranes around the eye, giving rise to a condition known as xerophthalmia, or conjunctivitis.

But the shortage of vitamin A may result in a similar injury to the mucous membrane of some other part of the body with resulting trouble in the respiratory, or the digestive, or the excretory system. The pathological penalty may thus appear in whatever is the individual's weakest part, though the original nutritional fault was the same in all.

If, instead of the extreme deficiency of a laboratory experiment, there is, what more often occurs among people, a moderate shortage continuing for a considerable time, there is apt to result certain roughnesses, called Bitot spots, on the mucous membrane of the eye. Such spots have been found in a large proportion of the people who have been examined by experts using present-day methods. This is one of the reasons for the belief that many people who never show any gross symptoms of vitamin A deficiency do nevertheless pass through periods of shortage of this highly important substance.

This conclusion has also been reached through studies of the chemistry of vision, in which vitamin A is found to take an essential part. Shortage of vitamin A has been found to cause "night blindness," a diminution of one's ability to see in a dim light or to adapt one's vision to a change of intensity of illumination. Measurements of such visual adaptation with and without supplementary feeding of vitamin A have indicated that a large proportion of the people (even in a region of such rich agricultural productivity as Iowa) get less than enough vitamin A to enable them to make full use of the eyesight with which they are individually endowed.

The keenness of sight of aviators and of industrial workers is reported to have been increased, and the night accidents of automobile driving decreased, by diets of higher vitamin A value; and even if these reports lack the conclusiveness of laboratory findings, they bring us suggestions that should not be entirely ignored.

On the positive or constructive side the evidence is interesting and impressive. Rats resemble human beings very closely in their reactions to vitamin A, and in well-controlled experiments with large numbers of rats, extending through entire lifetimes and successive generations, it has been conclusively shown that food of high vitamin A value is a large factor in the building of hitherto accepted normal levels of performance to better health and longer life.

Obviously it is not possible to feed human beings for entire lifetimes in an equally controlled way; and, if it were, our longer life cycles would make a two-generation experiment require about a hundred years. But Corry Mann's experiments with growing boys¹¹ have shown, as will be explained more fully later, that extra vitamin A does lend an extra impetus even to an already normal rate of growth and development.

Thus it is clear that the vitamin A value of a food is an important factor in its nutritive value, and in determining how prominent a place it should have in a dietary or food supply. Table 4 shows the vitamin A values of typical foods. It will be seen that the green and yellow vegetables, butter, and eggs, and also dried apricots are rich in vitamin A value. Milk contains considerably less per pound, but when used in such quantity as is desirable from the general view of its nutritive value it becomes one of the major sources.

Early in the modern era of nutritional knowledge, McCollum pointed out that, of the then-known nutrients, calcium and vitamin A were especially liable to be deficient in everyday dietaries; and that milk and green leaf vegetables are the two types of food which are rich in both these nutrients. He therefore proposed the term "protective"

¹¹ MANN, H. C. DIETS FOR BOYS DURING THE SCHOOL AGE. [Gt. Brit.] Med. Res. Council Spec. Rpt. Ser. 105, 81 pp., illus. 1926.

for these two types of food. Later, with growing knowledge and appreciation of other vitamins, the use of this term was extended to fruits, milk, and vegetables generally.

TABLE 4.—*Approximate vitamin A values of the edible portion of some typical foods*

Food	International units	
	Per 100 grams	Per pound
Fish-liver oils ¹ -----	200, 000–300, 000	About 1,000,000
Deep-green leaves such as those of broccoli, chard, dandelion, escarole, kale, mustard, spinach, turnip tops-----	10, 000– 20, 000	45, 000–90, 000
Broccoli, entire edible part-----	3, 000– 9, 000	13, 000–40, 000
Carrots, sweetpotatoes, apricots (dried)---	2, 000–10, 000	9, 000–45, 000
Butter-----	2, 000– 4, 000	9, 000–18, 000
Eggs, cheese ² -----	1, 000– 2, 000	4, 500– 9, 000
Tomatoes, cantaloup-----	900– 1, 300	4, 000– 6, 000
Milk-----	200	900
Potatoes ³ -----	30– 40	140– 180

¹ Figures here given represent a presumably safe average for fish oils generally, including the long-used cod-liver oil. There are, of course, particular species of fish such as halibut and percomorph, the liver oils of which have much higher vitamin A values.

² Including common American cheese (Cheddar type) and other kinds made from whole milk.

³ Breeding experiments for the production of potatoes of distinctly higher vitamin A value have been reported.

Dietary Allowances

The dietary allowances of vitamin A value recommended by the National Research Council are shown along with those for thiamine (vitamin B₁), riboflavin (vitamin B₂ or G), and vitamin C, in table 5. From this table it will be seen that the vitamin A and vitamin C requirements are (like those for protein and calcium) considered to be practically independent of the degree of muscular activity, while the requirements for thiamine (vitamin B₁) and riboflavin (vitamin B₂ or G) are held to run approximately parallel with the energy (calorie) requirements. This is because thiamine at least, and probably also riboflavin, is directly concerned with the oxidation process involved in utilizing the fuel foodstuffs as sources of energy in the body as will appear further in the section which follows.

Thiamine (Vitamin B₁)

Studies of normal nutrition and of the disease beriberi both contributed to the discovery of the existence of the substance now named thiamine (or thiamin, or thiamine hydrochloride).

We recognize it now as a nutrient which is essential at all ages to the right use of the fuel foodstuffs in our bodily tissues. When the dietary is grossly deficient in thiamine the burning of the fuel foodstuffs and particularly of the carbohydrate in the body is interrupted. Deleterious products of incomplete oxidation then circulate in the blood and through the organs and, perhaps because of this, there is usually a failure of appetite and an onset of functional nervous disorder. One form is the disease beriberi, which has been very common in the

Oriental countries where large numbers of people live predominantly upon white rice.

Of much more frequent occurrence in the United States are the relatively mild but often long-continued shortages of thiamine which do not develop the typical symptoms of beriberi but may be responsible for much of our all-too-common ill-defined heart and nerve troubles. Dr. R. M. Wilder, of the Mayo Clinic, and his associates there have particularly emphasized the importance of the relatively high amounts of thiamine called for by the National Research Council recommendations, which are about double the minimum amounts which suffice to prevent beriberi.

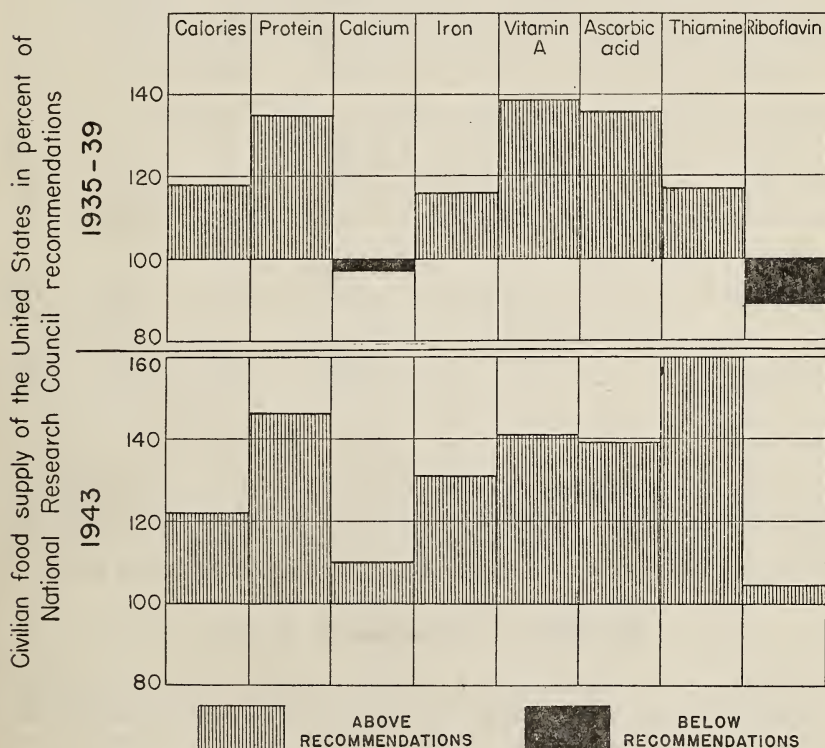


FIGURE 1.—Nutrition levels in relation to civilian requirements.

It was primarily to increase the amount of thiamine in our everyday dietaries that the National Research Council strongly supported the movement to enrich white bread and flour in thiamine, niacin (see p. 26), and iron. This enrichment in some measure relieves us of anxiety as to the adequacy of most American dietaries as sources of these nutrients. Figure 1 shows the striking recent increase of the thiamine content of the average American dietary. Yet the amounts of thiamine furnished by other foods are still of some practical significance, especially as some people are very negligent of bread as food.

Data on thiamine content of foods are therefore included in table 6 in parallel columns with the corresponding data for riboflavin.

TABLE 5.—*Vitamin allowances recommended by the National Research Council*¹

Sex-age group	Vitamin A value	Thiamine	Riboflavin	Vitamin C
	<i>Inter- national Units</i>	<i>Milligrams</i>	<i>Milligrams</i>	<i>Milligrams</i>
Man:				
Sedentary.....	5,000	1.5	2.2	75
Moderately active.....		1.8	2.7	
Very active.....		2.3	3.3	
Woman:				
Sedentary.....	5,000	1.2	1.8	70
Moderately active.....		1.5	2.2	
Very active.....		1.8	2.7	
Pregnancy (latter half).....	6,000	1.8	2.5	100
Lactation.....	8,000	2.3	3.0	150
Children:				
Under 1 year.....	1,500	.4	.6	30
1-3 years.....	2,000	.6	.9	35
4-6 years.....	2,500	.8	1.2	50
7-9 years.....	3,500	1.0	1.5	60
10-12 years.....	4,500	1.2	1.8	75
Girls:				
13-15 years.....	5,000	1.4	2.0	80
16-20 years.....	5,000	1.2	1.8	80
Boys:				
13-15 years.....	5,000	1.6	2.4	90
16-20 years.....	6,000	2.0	3.0	100

¹ See footnote 4, p. 6.

Although the daily allowances of these two B-vitamins are given in milligrams in table 5, the amounts in typical foods are given in micrograms in table 6 to avoid the inconvenience of small fractions. A microgram is a thousandth of a milligram, or a millionth of a gram.

Riboflavin (Vitamin B₂ or G)

Riboflavin, "the second member of the B-group of vitamins," is an important factor in the oxidation enzymes¹² of our tissues and in the maintenance of their stamina and resistance to strain and to several diseases.

With riboflavin as with calcium, recent research has shown that there is a wide zone between, on the one hand, the amount just sufficient for apparently normal health, and, on the other hand, the amount which yields best results.

From the minimal-adequate level as a starting point, successive enrichments of the dietary, or food supply, in its riboflavin content yield successively higher individual and family health up to intake levels more than twice that of minimal need.

Logically, therefore, food supplies should contain more riboflavin than the amount demonstrably needed for maintenance of health.

¹² Enzymes are organic substances formed in living tissues and functioning by favoring or expediting—stirring up or speeding up—some of the natural chemical reactions that are involved in our nutritional and other life processes.

Actually, however, they often contain less. Riboflavin deficiency has recently been found to be of rather frequent occurrence in various parts of the world. Now that, through use of the newer knowledge of nutrition, pellagra (see Other Vitamins, p. 26) has been largely conquered in this country, riboflavin deficiency is reported to be the most frequent vitamin deficiency in the southern part of the United States—as it also is in India.

There is some difference of expert opinion as to interpretation of certain of the milder symptoms in each case so that the line between pellagra and riboflavin deficiency cannot always be drawn sharply. In any case there is no doubt that many diets are too low in riboflavin for best results. It thus becomes apparent that the riboflavin content of food, or of a dietary, or a food supply, is an important factor in its nutritive value.

TABLE 6.—*Approximate average thiamine and riboflavin content in 100 grams edible portion of some typical foods*

Food	Approximate measure	Thiamine	Ribo- flavin
		Micrograms	Micro- grams
Beans, dried.....	½ cup, after baking.....	500	300
Beans, snap.....	¾ cup 1-inch pieces.....	75	110
Beef muscle.....	3.5 ounces.....	150	220
Bread, white, <i>enriched</i> ¹	4 to 5 slices.....	¹ 240	¹ 154
Bread, white, not enriched.....	4 to 5 slices.....	About ² 60	² 104
Bread, whole-wheat.....	4 to 5 slices.....	³ 300	² 130
Broccoli.....	1 cup, cooked.....	100	300
Cabbage, headed.....	1½ cups, chopped, raw.....	100	60
Cantaloup.....	¼ melon 5 inches in diameter.....	60	70
Carrots.....	¾ cup ¼-inch cubes.....	100	70
Eggs.....	1.8 eggs.....	150	350
Kale.....	1 cup, cooked.....	150	500
Liver ⁴	3.5 ounces.....	350	2, 800
Milk.....	0.45 cup.....	40	200
Orange, or juice.....	1 small orange, or ⅔ cup juice.....	100	50
Peas, green, fresh.....	¾ cup, shelled.....	400	200
Pork muscle.....	3.5 ounces.....	1, 000	240
Potato.....	1 small; ¾ cup, riced.....	175	42
Sweetpotato.....	1 small.....	100	80
Tomato, or juice.....	1 average-sized, or ⅔ cup juice.....	90	45

¹ According to the official definition and minimum standards effective from Oct. 1, 1943.

² Varies with kind of yeast and amount of milk used in bread making.

³ Whole-wheat flour should insure the amounts stated, while use of milk and special yeast in bread making may result in much higher values.

⁴ Average of kinds commonly used as human food.

It is very noteworthy that the same article of food—milk—is the outstanding dietary source of both the nutrients which are most often below current scientific standards in the American dietary—calcium and riboflavin. This fact would in itself constitute a strong reason for developing milk production and use into a more prominent place in the American food economy. There is also another strong reason in the fact that the milk cow is a more efficient converter of the protein of field crops into human-food protein than is any other class of farm animal. Swine rival milk cows as energy transformers but not in the economy of utilization of most of the specific nutrients.

Thus, it will importantly serve the nutritional well-being of the people, at the same time that the agricultural economy is improved and stabilized, when these nutritional facts become more fully and generally appreciated, with a resulting shift toward a higher proportion of dairy cattle in the American farm-animal population. Also, a larger proportion of the milk solids produced should be brought into human consumption.

Thiamine and Riboflavin in Foods

Table 6 illustrates several important facts about the thiamine and riboflavin values of foods.

Whole-wheat and enriched white bread are seen to contain about five and four times as much thiamine, respectively, as white bread that is not enriched.

The cereal grains and the breadstuffs, like seeds and their products generally, contain more thiamine than riboflavin; and this is also strikingly true of pork muscle. Milk, eggs, meats other than pork, and the green leaf vegetables contain more riboflavin than thiamine.

Fresh green peas are rich in both these vitamins, thiamine predominating as in seeds generally. Snap beans, with their very undeveloped seeds and their thick green pods, contain more riboflavin than thiamine. So also, and in more striking degree, does the edible portion of broccoli, which consists mainly of flower buds with more or less of the adjacent leaves and tender green twigs.

The thiamine and riboflavin content of other vegetables and of fruits range around a general average of about 100 micrograms per 100 grams. This is only 1 part in a million, which sounds so small that it is too often treated as negligible. But for people who consume the liberal amounts of fruits and vegetables that the newer knowledge of nutrition favors, these foods become important sources of both thiamine and riboflavin.

Vitamin C (Ascorbic Acid)

The name ascorbic acid was given to vitamin C because it is the substance which prevents scurvy and cures it with dramatic promptness if it is not too far advanced. But when scurvy is ancient history, vitamin C will still be a substance of immediate interest because of its important nutritional functions.

It is essential to the integrity of the cement substance which lies between the cells of the body's various tissues and keeps each cell properly set and supported for the performance of its part in the work of the body. This involves, among other things, the prevention of hemorrhages or oozing of blood through tissue, which in a shortage of vitamin C may occur in almost any part of the body; the maintenance of a healthy condition of the gums and teeth; the development and maintenance of right relations between the ends of growing bones, and of a matrix suitable for normal calcification within each bone; the prevention of some forms of anemia; and the regulation of heart muscle and of muscle tone generally.

Moreover, there are interesting indications that vitamin C may have an important part in what has been attractively called "the preservation of the characteristics of youth"; and King and Menten¹³ have definitely shown that liberal amounts of vitamin C in the body increase its ability to resist the toxins formed by certain species of bacteria. So it is clearly well worth while to take account of vitamin C in our choice and use of food even if we are already living safely above the scurvy level.

Table 7 shows the approximate average vitamin C content of typical foods. These values are for the raw foods. Vitamin C is a substance which is easily decomposed, especially when heated in contact with air and with catalytic substances which increase the rate of oxidation. Foods in which vitamin C is a significant factor of nutritive value should therefore be cooked and handled with as little exposure to air or contact with copper, and for as short a time as possible. High temperatures should be used only when they make possible a marked shortening of the cooking time; and no soda or other alkali should be added to any food in which one desires to conserve vitamin C.

TABLE 7—Vitamin C in edible portion of some typical raw foods

Food	Measure of 100-gram portion	Milligrams per 100 grams
Turnip greens.....	3½ oz., raw; ½ cup, cooked.....	150
Broccoli.....	1 cup, cooked.....	115
Cauliflower.....	½ small head.....	76
Cabbage.....	1½ cups, chopped, raw.....	58
Orange, or juice.....	1 orange, or ½ cup juice.....	54
Strawberries.....	¾ cup.....	53
Grapefruit, or juice.....	½ cup.....	39
Turnips.....	¾ cup ½-inch cubes.....	31
Cantaloup.....	¼ melon 5 inches in diameter.....	29
Peas, fresh green.....	¾ cup, shelled.....	24
Tomato, or juice.....	1 average-sized, or ½ cup juice.....	23
Sweetpotato.....	1 small.....	19
Snap beans.....	¾ cup 1-inch pieces.....	19
Potato.....	1 small, 2½ inches in diameter.....	19
Onions.....	½ cup, sliced.....	18
Lettuce.....	6 large leaves (½ head).....	11
Peach.....	1 medium-sized.....	8
Carrots.....	¾ cup ½-inch cubes.....	6
Apple.....	1 average-sized.....	5
Grapes.....	½ cup (20 large-sized).....	4
Milk.....	½ cup, scant.....	2

There are two facts of perhaps greater importance than even most students of nutrition realize regarding the vitamin C values of common foods. (1) Some foods hold their initial vitamin C values much better than do other foods—tomatoes much better than cabbage, for example. (2) Some foods, such as apples and potatoes, while not outstanding in their vitamin C content or in their retention of it, yet because of their general popularity may be used so abundantly as thus to be important sources, provided they are handled with reason-

¹³ KING, C. G., and MENTEN, M. L. THE INFLUENCE OF VITAMIN C LEVEL UPON RESISTANCE TO DIPHTHERIA TOXIN. Jour. Nutr. 10: 129-140; 141-155, illus. 1935.

able care. Apples may be largely eaten raw and in season; potatoes should be prepared with as little exposure to air, and eaten with as little delay after preparation, as is reasonably possible. Cabbage, broccoli, and turnip greens should be consumed as freshly and with as little cooking as possible.

Vitamin D (The Antirachitic Factor)

Vitamin D prevents rickets. To be exact, two important substances and several of less practical significance have this effect; but for convenience we apply the simple term vitamin D to any or all of the group of organic substances that possess the antirachitic property.

This factor is fat-soluble. It occurs to some extent in milk fat, more largely in egg fat, and in much greater concentration in fish-liver oils.

As compared with amounts of vitamin D easily obtainable from fish-liver oil, those in milk and eggs are usually considered negligible. Another good way to get vitamin D is to produce it in the body by exposing the skin to direct sunshine, or artificial light containing suitable ultraviolet rays.

When sunshine is not available the National Research Council recommends that children be given 400–800 units of vitamin D a day. Doubtless adults also should either have a significant amount of sunshine or more vitamin D than they probably get in their everyday food. (The United States Pharmacopeia unit and the International Unit of vitamin D are the same.)

Other Vitamins

Among other vitamins than those introduced above, there are additional members of the B group, and also vitamins E and K; but the purpose of this bulletin is not to cover all vitamins that human beings require—only those that are now known to be factors of practical importance in food values and diet planning.

In this connection the case of niacin (formerly and still sometimes called nicotinic acid) requires a special explanation. It is often spoken of as preventing and curing pellagra; and the National Research Council's recommendations include figures for niacin set down in parallel column with those for the nutrients previously discussed, but the case is not really parallel for a combination of reasons.

Niacin prevents and cures the deficiency condition called black-tongue in dogs, the symptoms of which correspond to some of the symptoms of pellagra; but the curing of these symptoms by niacin does not restore to full health the pellagra patient as actually met. Niacin deficiency is only a part of what is wrong with most pellagra patients; and the actual effectiveness of foods is not fully indicated by such estimates of their niacin content as are yet available—at least not in all cases.

Present methods of measuring niacin seem to be fairly accurate for meats and cereals but not for milk and vegetables and probably not for eggs. Great uncertainty also attaches to present estimates of the

amount of niacin which the food must furnish in order to meet the needs of human nutrition; and it may be that milk and perhaps eggs and vegetables give rise to niacin in the digestive tract of man, while other foods do not, or not in corresponding degree.

The recommendation of the National Research Council that allowances of niacin be 10 times as much as of thiamine is confessedly very sketchy and tentative. It is therefore likely to be seriously misleading if we attempt, in the present very incomplete state of our knowledge, to treat niacin values of foods and requirements in nutrition in the same manner as the data for other nutrients.

For the purpose of ensuring the nutritional adequacy of food supplies we may much better emphasize the practical findings of the United States Public Health Service and the United States Department of Agriculture that pellagra is prevented by diets which include, daily, the equivalent of a quart of milk or buttermilk or a pint of evaporated milk; 6 to 8 ounces of dried skim milk, lean meat, canned salmon, or peanut meal; or 1 pound of fresh or canned collards, kale, green peas, or turnip greens.

When the total representation of meat, fish, eggs, milk and vegetables in the day's dietary amounts to the equivalent of any one of the items just mentioned we may trust that the need for both niacin and any recognized or unrecognized co-preventives of pellagra will be supplied.

Grouping of Foods with Regard to Nutritive Value and Place in the Diet

A child of 4 formulated her own classification of foods: "Some things we eat help me grow up. Some just stop me from being hungry."

This is a true grouping so far as it goes, and in the past many people have gone through life with concepts of food values about as simple as this of the 4-year-old girl.

Early in the era of the newer knowledge of nutrition it was proposed that a few kinds of food be grouped for emphasis under the term "protective foods," because they are effective in making good the nutritional shortages that were found most frequent in dietaries and food supplies. In course of time, this term came to stand loosely for those foods which are highly significant as sources of mineral elements and vitamins, in contradistinction to such foods as are chiefly sources of the longer known nutrient factors—calories, or protein, or both. This was a useful means of getting a first grasp of the importance of the newer knowledge of nutrition.

Now, however, we find it necessary to recognize two limitations of its usefulness. First, purveyors of certain foods to which it distinctly did not apply, have nevertheless been able to stretch the word "protective" so as to use it in sales promotion in ways quite different from that in which it was used in the teaching of food values by nutritionists, so that the term became misleading to some people and meaningless to others. Secondly, any attempt to divide all food

commodities into only two groups is too simple to be a satisfactory basis for the application of present-day nutritional knowledge in the building of dietaries which shall be at once well-balanced and economical.

The national nutrition education campaign of the United States Department of Agriculture and the War Food Administration has given wide circulation to a sevenfold grouping of what are called basic foods. Preceded by the admonition to eat at least one food from each of these groups every day and followed by the remark that then you may eat any other foods you like, this grouping is as follows: (1) Green and yellow vegetables; (2) oranges, tomatoes, grapefruit—or raw cabbage or salad greens; (3) potatoes and other vegetables and fruits; (4) milk and milk products—fluid, evaporated, dried milk, or cheese; (5) meat, poultry, fish, or eggs—or dried beans, peas, or nuts, or peanut butter; (6) bread, flour, and cereals—natural whole-grain or enriched or restored; (7) butter and fortified margarine (margarine with added vitamin A).

For purposes of more explicit planning of dietaries, and also for discussions of production goals and of the adequacy of national food supplies, the Department of Agriculture makes much use also of the following *Eleven Food Groups*:¹⁴ (1) Milk and such of its products as retain its nonfat solids; (2) citrus fruits and tomatoes; (3) green and yellow vegetables; (4) potatoes and sweetpotatoes; (5) dry mature beans and peas, and nuts; (6) other fruits and vegetables (than those in preceding groups); (7) eggs; (8) lean meat, poultry, and fish; (9) breadstuffs and cereals; (10) fats; (11) sugars.

Complete dietaries can be planned in terms of so much food from each of these groups, the elevenfold grouping being explicit enough for all the everyday purposes of both food budgeting and planning of meals.

It is worth while to note just how the two groupings thus used by the Government for its different purposes compare with each other. The plan of a "basic seven group" plus "other" foods (*a*) brackets meats with eggs, legumes, and nuts; (*b*) brackets potatoes with other vegetables; and (*c*) relegates to the other-than-basic group both sugars and all vitamin-poor fats and grain products.

The nutritional characteristics of each of the main groups of foods are as follows:

Green and Yellow Vegetables

Green and yellow vegetables are grouped together primarily because of their high vitamin A value. From this viewpoint three other foods are entitled to membership in this group: (1) Sweetpotatoes, which because of their high carbohydrate content and energy value and their traditional place in southern menus are, in the eleven-group plan, bracketed with potatoes instead; (2) tomatoes, which are good sources of vitamin A but more outstanding in their vitamin C content; (3) apricots, fresh, canned, or dried, which fail of inclusion in the title of this group only because of the desirability of keeping it short.

¹⁴ The 11 groups may be numbered and arranged in any order deemed most convenient.

Green and yellow vegetables have been a fairly constant factor in the American food supply of recent times, the per caput consumption having been 80 to 90 pounds a year. This might well be increased to at least 100 pounds per person as an immediate goal for all families, with an open-minded attitude toward further stepping-up to 120 and perhaps 150 pounds a year.

To what extent this increased supply shall come from family gardens and to what extent from increased growing of truck crops need not be argued, for both are easily practicable.

Broccoli is worthy of special mention as an interesting and relatively sure-crop vegetable, of which the edible portion, consisting of the unique flower bud, the adjacent green leaves, and the accompanying tender twigs, can be harvested without injury to the plant, which continues to produce throughout a long season.

Kale is another green deserving of a larger use as human food. It will be well if the greens of the Goosefoot family, including spinach and beet greens, with their undesirably high content of oxalic acid, are steadily more and more displaced by greens relatively free from oxalic acid. This preferable group includes among others broccoli, loose-leaf cabbage and lettuce, collards, turnip tops, mustard greens, and kale.

Some of the green vegetables deserve inclusion also in the following "vitamin C foods" group.

Citrus Fruits, Tomatoes, Raw Cabbage, and Salad Greens

The fruits and vegetables named are outstanding sources of vitamin C, as are also cantaloups and raw strawberries in their seasons. Science now considers that a liberal amount of vitamin C in the diet is a sound nutritional investment and not a luxury or self-indulgence, as was previously supposed.

The citrus fruits (chiefly oranges, grapefruit, and lemons) and tomatoes have the very important advantage that they are easily and safely canned and that they hold their vitamin C values remarkably well as compared with other foods. Partly for this reason and partly to avoid overlapping of food groups, the citrus fruits and tomatoes often constitute a separate group.

Now that oranges and grapefruit and their canned juices have become so abundant and cheap (at least for the majority of people in the United States) they are usually and properly considered the standard source of vitamin C. Cantaloups and fresh strawberries are an equally rich source of vitamin C for the people to whom they are available. Note also the vitamin C values of the greens included in table 7, page 25.

Raw cabbage and salad greens are bracketed with citrus fruits and tomatoes in the simplified seven-group classification used by the Department of Agriculture in some phases of its food education work. To the extent that one can purchase cabbage strictly fresh (or harvest his own) and eat it raw without delay, this will often be a very economical source of vitamin C. But vitamin C disappears more rapidly in cabbages or cabbage juice than it does in citrus fruits or tomatoes or their juices, under like conditions. The figure given in table 7 above is the writer's best estimate of the average of all available evi-

dence; but others estimate that by the time raw cabbage reaches actual human consumption in large-scale feeding establishments, such as the Army mess, it can be trusted to furnish only about three-fourths as much.

Both these estimates may be substantially correct. Obviously, they imply a relatively large deterioration of vitamin C value of cabbage, even raw, on the way to consumption such as does not occur in citrus fruits or tomatoes.

A relatively large loss of vitamin C in cooking is commonly expected but the actual loss may be widely different in different foods under like conditions or in the same food when cooked in different ways.

Potatoes and Sweetpotatoes

Potatoes and sweetpotatoes are grouped together because of their similarity in high carbohydrate content and energy value and because one or the other or both together will usually be found playing a prominent and practically distinctive part in the American dietary. Whereas they are not concentrated sources of vitamin C, their large use makes them fairly important sources. They differ in that potatoes are poor, but sweetpotatoes are rich, in vitamin A value.

Mature Beans and Peas, and Nuts

Mature beans and peas, and nuts are valuable for their high protein and thiamine content, and they also contain worth while amounts of other vitamins of the B group and of calcium, phosphorus, iron, and other mineral elements. Of late we are learning to realize their importance as economical extenders of, and alternatives for, meat dishes.

Other Vegetables and Fruits

Fruits and vegetables of other types than those shown in table 7 or covered in the foregoing paragraphs are not such outstanding sources of any one nutrient but generally have well-balanced mineral contents and vitamin values such as to make it well worth while to include generous amounts of these other fruits and vegetables in the dietary. Emphasize each in its own season when it is at its best and cheapest.

Grain Products: Breadstuffs and Cereals

The fruits and vegetables mentioned, while bracketed mainly on grounds of their nutritional characteristics, also to a large extent fall into natural groups as constituting organs of plants. Fruits, flower buds, leaves, stems, roots, and tubers have been included; and one important group of seeds—those of the legumes and nuts.

Another very important group of foods consist of the seeds of the cereals, sometimes eaten in their natural state, sometimes after primitive pounding or milling to remove their fibrous outer layers, and sometimes after elaborate processing. In general, rice in the Orient

and wheat in the western world, are the cereals preferred by most people. Wheat is eaten chiefly as bread.

In the world view this is at least equally true if we let the word bread stand for all grain products. Being relatively cheap, easy to keep or transport, and universally recognized as good food, grain products furnish from about 30 to at least 70 percent of the total calories in the food supplies of different countries.

Thus the breadstuffs and other grain products are very important in the food supply. This food group is (*a*) an excellent source of energy, (*b*) a good source of protein and some of the B-vitamins when used in the form of whole-grain products, but (*c*) not an adequate or well-balanced source of vitamins and mineral elements in general. Specifically, the grains are poor in calcium and riboflavin and practically devoid of vitamins A and C.

The milling of grains to such refined products as white rice, patent flour, and new-process corn meal robs them of most of their mineral and vitamin values, and greatly lowers the nutritive value of their proteins. Whereas the amount of protein we absorb from white bread and brown is not very different, there is a great difference in nutritional value in favor of the proteins in the germ, or embryo, of the grain and the accompanying parts which the modern milling, and other refining processes to which white flour is subjected, eliminate.

The recent program of "enriching" white flour and bread, and "restoring" refined breakfast cereals, atones in fair measure for the processing losses in iron, thiamine, and niacin but does not restore the lowered protein value. This latter can, however, be compensated more or less fully by the use of soy flour or skim-milk powder in bread making. The latter also, when used in liberal proportion, very greatly improves the bread as a source of calcium.

The consumer should bear in mind that the term "enriched" does not guarantee that milk has been used in the making of the bread. The consumer must ascertain, as a separate item of information, whether the bread bought has been made with milk powder and if so with how much. Six percent as much skim-milk powder as flour can be used in bread making with distinct nutritional advantage and no detriment to the physical properties of the bread. It is very desirable that such addition become an established practice in bread making.

Milk and Its Products Other Than Butter

Milk, whether in its natural fluid form or fermented or evaporated or dried, and products which, like cheese, cream, and ice cream, retain in fair proportion the proteins, vitamins, and mineral elements of milk, constitute an extremely important food group.

Recent research reinforces the time-tested principle that "the dietary should be built around bread and milk." This principle does not exclude anything from the dietary but only emphasizes the foods which may be thought of as occupying the central place in the dietary picture: Bread, because so far as it goes, it brings so much food value at so little cost; and milk, because it so efficiently and economically supplements and balances the bread.

This important fact has been fully reaffirmed in the same recent years which have taught us also to appreciate fruits and vegetables more highly than we formerly did.

In all parts of the United States and at all economic levels, the most certain way of improving our dietaries is by increasing the proportions of fruits, vegetables, and milk in them. As to just how much milk one should use, there is room for individual self-determination. In most cases a good general guide is to provide at least three cups a day for each person and four cups (a full quart) for a child or for a pregnant or lactating woman.

Besides being an excellent food in many other respects, milk is outstanding in three ways which make its larger production and consumption desirable from both the individual and the community or national point of view. It represents the most economical and efficient conversion of the protein of field crops and pastures into human-food protein of high nutritional efficiency. And milk is relatively richer than any other food in the two nutrients—calcium and riboflavin—in which American dietaries most need, and will best repay, enrichment.

These strong reasons for a larger conversion of food-producing resources into milk are only now coming to be generally appreciated, and under our economic system can become fully effective only as the increased production of milk is supported by a corresponding growth of consumer demand. While the "melancholy mildness" of milk in its physical properties makes it less interesting to consume than are many other foods, yet no other food exceeds milks in the possibilities it holds for the improvement of human life through better nutritional well-being.

Eggs

In a general way, eggs are intermediate in their nutritional nature between milk and meat. The fact that they differ in some respects from both, and also have special uses in cookery, justifies their being treated as a type in themselves in the division of foods into 11 or more groups, while in the simpler teaching plan, based on 7 food groups, eggs are classed as full alternatives with meats, fish, and poultry. The consumption of eggs in the United States has grown to a 1943 average of 28 dozen per person per year.

Nutritionally, eggs are a full equivalent for meat, and the wartime increase in egg consumption may have been in some measure connected with the reduced amount of meat available for civilian consumption. Whether a further increase of egg consumption, if accompanied by the full American average consumption of meat, would be a dietary improvement is an open question. No doubt, however, there are many low-income families whose dietaries are poor in eggs and who would gain nutritionally if they could get at least the long-standing American average of about five eggs a person a week.

Meats, Including Fish and Poultry

Flesh, fish, and fowl are chiefly significant nutritionally as rich sources of protein accompanied by moderate amounts of several of the

B vitamins. They are grouped together for this reason, and for the same reason eggs, legumes (beans, peas, lentils, soybeans), and nuts are included in the broader grouping.

These foods enrich the dietary in protein and often in fat. Also the proteins of foods of this group tend to supplement the proteins of breads and cereals in nutrition; but except for a somewhat better riboflavin content, these foods have about the same mineral and vitamin shortages as do the grains, so that they do not balance the breadstuffs in an all-around way, as milk does.

When the dietary includes as much of grain products as it well may for economy and as much milk as is desirable for the reasons already explained, the protein needs of good nutrition will have been very nearly if not fully met. Then one moderate serving a day of meat or an alternative from this group will be ample.

Quantitative statements about meat consumption are not always strictly comparable because meats consisting largely of fat are sometimes included with meats and sometimes with fats.

Butter and Other Fats

In their high energy value and property of staying longer in the stomach than other foods do, all the commercial food fats count together. Butter may be given a separate place because of its vitamin A value and its origin as a dairy product. Margarine for table use is now commonly fortified with vitamin A. Some nutritionists do and others do not treat such fortified margarine as a full equivalent of butter. This somewhat controversial question will not be argued here.

But how about the competition between meats and fats for the consumer's food money? We recognize that "Aside from all questions of nutritional need, eating has an immense vogue as an amusement." Some people find more pleasure in eating more meat; others in eating more of butter and perhaps other fats. In the fact that under wartime conditions families have differed in the proportions in which they divide their ration points and in their neighborly talking-over of their respective uses of these points, it has become clear that American pre-war food habits (except among the very poor) had been so free in the use of both meats and fats that with either or both of these reduced, we can still enjoy excellent nutrition.

Of the foods that are most desired overseas and most practicable to ship (such as wheat, meat, fats, and sugar) we can well share liberally with other nations. Then, by eating as alternatives larger proportions of the fruits, vegetables, and milk which are too watery and perishable for such shipment except when dehydrated, we can improve our own nutritional well-being at the same time.

Nor need we assume that if our food economies result in our making more use of bread we shall need to eat more butter or other fat with it. The bread can be eaten in the form of toast, if preferred, with any other food the meal includes; for example, with milk, or fruit, or coffee with cream or milk.

The nutritive value of the diet need not suffer from an increased proportion of bread or a decreased proportion of such fats as butter and margarine, if accompanied by increased proportions of fruit, vegetables, or milk.

Sugar and Sweets

Sugar in moderation helps the consumption of some other foods, and may have something of a special value as quick fuel though most nutritionists give little if any weight to this latter claim. The recent rationing of sugar in the United States decreased its consumption here materially without causing any apprehension among nutritionists beyond an anxiety that rationing of sugar should not be allowed to interfere with the preservation of fruit.

If the world production of sugar should remain fairly constant, we could well afford nutritionally to have this sugar distributed as evenly as practicable to all the world's people.

For at least a century (from the 1820's to the 1920's) there was a steadily increasing consumption of sugar per person in the United States.

Experts differ in the details of their estimates, but the general picture is an increase from about 10 pounds to about 100 pounds of sugar per person per year. This difference of 90 pounds of sugar a year means 444 calories a day of other food displaced by sugar, with a reduction of about one-sixth in the mineral and vitamin values of the average American dietary as a consequence of the increased use of sugar.

Another change in food habits unfavorable to nutritional well-being occurred more abruptly when in the space of a few years, around the 1880's, the milling of wheat was almost completely changed from grinding with millstones to the use of the roller process, and so to the production of patent and similar nutritionally impoverished flours for bread making.

With the growth and diffusion of nutritional knowledge one of these influences has been checked and the other ameliorated. Sugar consumption in the United States seems to have reached its "plateau" at about 100 pounds per person per year; and the impoverishment of white flour by the roller process of milling has been in part (but only in part) counteracted by the addition of iron, thiamine, riboflavin, and niacin to the flour or in bread making.

What Our Food Habits Mean and Could Mean

Since about the turn of the century, and growing gradually with the newer knowledge of nutrition, there has been a trend toward increased use of fruits, vegetables, and milk. This has already appreciably improved the average or typical American dietary; and it is reasonable to hope and expect that this constructive improvement of our nutrition through a more scientifically guided emphasis on the choice and use of natural foods will continue.

The scientific researches of McCollum of Johns Hopkins, of the late Dr. Mary S. Rose, of Drs. Stiebeling and Phipard of the Department of Agriculture, and others, have fully established the fact that American food habits, at all economic levels, are most commonly such as are best improved by increasing the proportion of fruits, vegetables, and milk they contain.

In the foreword to the Yearbook of the Department for 1939, the then-Secretary Henry A. Wallace wrote: "Fifty percent of the people of the United States do not get enough in the way of dairy products, fruits, and vegetables to enable them to enjoy full vigor and health. * * *" And later, in the same Yearbook, page 41, we read: "There is nothing mysterious about the practical application of modern knowledge of nutrition. Leaving out all the technical details, it says simply that the majority of people need to get more milk and milk products, eggs, and certain fruits and vegetables than they now get."

Fortunately the majority of people instinctively eat to about their total food-calorie need—otherwise there would be more overweights and underweights than there are now. So when we followed the advice to take more fruits, vegetables, and milk, we were in position to spare more of our supplies of meats and fats for war demands; and quite rightly, for of these our previous levels of consumption were high enough so that to reduce them considerably was entirely consistent with our being excellently nourished.

As was to be expected, the effects of the war years upon our food conditions have been mixed, accentuating the scientific evolution of our food habits in some respects, while tending to interrupt it in other respects or at particular times and places.

Table 8 shows our estimated food consumption for 1935-39, 1940, 1941, 1942, and 1943 in terms of food groups, and table 9 the corresponding estimated amounts of certain nutrients reaching consumers—i. e., contained in the food as it entered the kitchens—in 1935-39 and 1943, with the recommended allowances of the National Research Council in a parallel column.

TABLE 8.—*Estimated civilian food consumption on a per capita basis, by food groups, United States, 1935-39, 1940, 1941, 1942, 1943*¹ (retail-weight basis)

Food group	Unit	1935-39	1940	1941	1942	1943
Milk ² -----	Quarts----	207	213	218	232	247
Citrus fruit and tomatoes----	Pounds----	78	88	90	87	³ 87
Leafy, green, and yellow vegetables-----	Pounds----	80	83	84	90	³ 81
Potatoes and sweetpotatoes----	Pounds----	144	137	134	133	150
Dry beans and peas, and nuts----	Pounds----	16	16	16	17	19
Other fruits and vegetables----	Pounds----	199	197	205	183	³ 150
Eggs-----	Dozens----	24	25	25	25	28
Meat, fish, and poultry (excluding bacon and salt side)----	Pounds----	136	147	150	149	147
Flour and cereals-----	Pounds----	200	201	204	209	203
Fats and oils (including butter, bacon, and salt side)-----	Pounds----	65	72	71	68	66
Sugars and sirups-----	Pounds----	105	100	115	107	94

¹ Estimates of the U. S. Bureau of Agricultural Economics, based on production (including that on farms for home use), imports, exports, and changes in stocks on hand.

² Includes fluid milk and its equivalent in the forms of condensed, evaporated, and dried milk, cheese, cream, and ice cream. The equivalences are figured on the basis of the nonfat milk solids.

³ Products of home gardens (not on farms) doubtless increased the amounts here estimated.

No deduction has here been made for losses of nutrients in home cooking. How large these losses usually are or need be is now a subject of active research. Meanwhile, the fact that the National Research Council recommendations were set at liberal levels to provide

for all probable contingencies, may more or less balance the absence of specific deductions for cooking losses—our knowledge both of actual requirements and of average losses being confessedly sketchy as yet.

Figure 1 shows graphically the amounts contained in our foods, as just explained, in 1935-39 and in 1943 of each of eight nutrients, expressed in percentages of the National Research Council's recommendation. (See p. 21.)

Except for relatively few persons whose food reactions or nutritional processes are abnormal or idiosyncratic and who should be under individual medical guidance, the relationships shown in table 9 and figure 1 may be summarized somewhat as follows:

Of calories and protein our national food supply furnishes amounts sufficiently above our demonstrable needs to approximate the optimum, or possibly more. Of course there are underprivileged families who get much less than their share and whose dietaries may be poor in nearly all respects. But even among the sufferers from extreme poverty, calories and protein are not the most serious danger points, while in the great majority of American families these are so far on the safe side that we could not expect an increased consumption of calories or protein to bring any benefit to nutritional well-being.

Some people, who would accept this statement quite confidently insofar as it relates to calories, might still feel that a larger amount of protein would make us better nourished. This is chiefly because of the persistence of impressions derived from earlier times.

When vitamins were unknown and the nutritional significance of mineral elements was unappreciated, all the nutritional virtues of a food which are not explained by calories were attributed to its protein. For this reason, there was a long period in which science itself was overcredulous about the benefits the food proteins bring.

Moreover, that period of scientific development extended down to such recent years that it still has a very strong influence upon present-day habits of thinking. In addition, there is a traditional social and literary custom, unbroken since at least the time of Homer, of treating the meat dish as the main dish of the meal.

TABLE 9.—*Nutritive value of civilian per capita food supply, 1935-39 and 1943, and recommended dietary allowances*

Nutrient	Unit	Nutritive value per capita per day of civilian food supplies (raw-food basis)		Recommended dietary allowances, per capita basis ¹
		1935-39	1943	
Food energy	Calories	3, 250	3, 320	2, 730
Protein	Grams	88	95	65
Calcium	Grams	. 88	. 99	. 9
Iron	Milligrams	13. 9	15. 7	12
Vitamin A value	International Units	6, 700	6, 500	4, 600
Ascorbic acid	Milligrams	97	97	70
Thiamine	Milligrams	1. 75	2. 40	1. 5
Riboflavin	Milligrams	1. 96	2. 31	2. 2

¹ Allowances suggested by the Food and Nutrition Board of the National Research Council for 17 age sex-activity groups were weighted by the estimated number of persons in each group in 1943.

Undoubtedly, too, protein contributes to the so-called well-fed or full-fed feeling which follows a meal rich in this nutrient. For these various reasons the amount of protein desired may be much larger than the amount needed for even the best results. The recommendations of the National Research Council, allowing about 1 gram of food protein per kilogram of body weight per day for normal adult maintenance, are held by an independent reviewer (Prof. H. B. Lewis, of the University of Michigan) to be from half again to twice as much as the scientific evidence calls for.

On the other hand, the National Research Council's recommended allowance of 0.8 gram of calcium for normal adult maintenance provides but very little margin above the strict minimum requirements of the recent scientific evidence.

Average American food consumption, while much more than meeting the relatively liberal protein allowance, barely meets the much less liberal recommendation as to calcium. As shown in figure 1, the calcium of the average American dietary fell short of this allowance in 1935-39 and showed a very small margin in 1943.

The iron, thiamine, and niacin contents of our dietary have been materially increased since 1939 by the general introduction of enriched flour and bread so that on these points the average dietary now seems to carry ample margins for safety.

The vitamin A value and the vitamin C, or ascorbic acid, content of the average American food supply each meets the recommendations of the National Research Council with a fair margin to spare. Yet these factors need thought because of the unevenness of their distribution—and perhaps also rather wide individual differences in need or utilization. Careful examination of bodily condition by new and very delicate methods indicates that a large proportion of the people, even in our country of abundant resources, show signs of having been more or less handicapped by relative shortage of one or both of these vitamins at times. The indications of this may be only microscopic, and there may still be some differences of technical opinion among experts in their interpretations; yet there is sufficient objective evidence to call for greater care on our part to obtain dietaries of high vitamin A and C values for all our people.

In these cases of vitamin A and C, as well as of calcium and riboflavin, it is well to lay the emphasis upon increased production of the foods that can bring an abundance to all, rather than upon attempts to level consumption. There is no serious economic or other intrinsic difficulty in raising more of some of the foods that are rich in these nutrients.

The home garden can add importantly to the vitamin A and C values of the dietary of many families. In most home gardens the standbys are green beans, tomatoes, and leaf vegetables—all easy to grow and fairly sure crops. The tomatoes are relatively easy and safe to can and keep for winter, when they furnish a daily supply of vitamin C.

The green beans and leaf vegetables are a good source of vitamin A, which the body can store; so by eating them liberally in their season we can provide vitamin A for winter use, storing it "under our ribs instead of on the pantry shelves."

Riboflavin is, of all the nutrients of which our knowledge is sufficiently accurate and quantitative to permit this kind of comparison, the one least adequately furnished by the average American food supply.

It will be seen from table 9 and figure 1 that riboflavin was the point of greatest deficiency (as tested by the National Research Council's yardstick) in 1935-39; and, in early 1943, it was still below the level of the yardstick recommendation. Extension of the enrichment program to include riboflavin brought this just above the recommended level by the end of that year.

Not only is riboflavin the least adequately supplied in the average dietary, but it is also rather unevenly distributed when American family food records are grouped economically or geographically.

This means, among other things, that if average food supplies just matched average nutritional needs at all points, riboflavin would still be a point of more than average danger because of its uneven distribution. Partly for this reason and partly because liberal margins of riboflavin are not only good insurance but also a constructive means of building normal health and efficiency to higher levels, it is clear that a very large proportion of our people will be importantly benefited by getting more riboflavin in their food.

The Nutritional Improvement of Life

One of the things that have recently aroused the nutrition consciousness of the American people generally is the large percentage of our young men rejected in the national draft. It is high time for the public to awaken to the importance of food and nutrition; but a fuller study of the draft examinations has brought more of reassurance than alarm. The large number of rejections has been explained not by deterioration of the Nation's physique but by the fact that our national standard has advanced. The young men of 1942 were found to be about an inch taller and correspondingly better developed than were their predecessors of 1917 at the same ages.

Careful studies have also shown that the boys and girls of today enter college both younger and taller than their predecessors of 20 to 30 years ago. Doubtless several causes have contributed to this result. Important among these causes is nutrition.

While perhaps it has not been generally realized until recently, the newer knowledge of nutrition has been gradually improving the American norm of health and physique since very soon after the turn of the century. Now that scientific research has still further advanced our knowledge and made its application much clearer, there can and should be a fuller and more far-reaching nutritional improvement of human life.

Nutritional knowledge can serve each individual life, including those of people already passably well-nourished and healthy.

Boys in an English boarding school were studied by H. C. Corry Mann,¹⁵ whose findings were critically reviewed by Dr. Walter Fletcher,¹⁶ a physician and a member of the British Medical Research Council.

These boys had been and were fed a dietary planned with every regard for the welfare of those who were to receive it and explicitly characterized as meeting the standards of good medical men. Yet

¹⁵ See footnote 11, p. 19.

¹⁶ FLETCHER, W. M. THE URGENCY OF NUTRITIONAL STUDIES. *Nutr. Abs. and Rev.* 1: 357. 1932.

when a part of these boys were continued on this same dietary while others received a supplement of milk, or of butter, or of water cress, these latter made better gains in both height and weight. The best gains were made by those receiving the extra milk, and it was found that the supplemental feeding undoubtedly improved the rate of mental as well as physical development.

In Dr. Fletcher's words, while all were healthy and provided with a food supply "medically adjudged to be sufficient for healthy development, the boys were in fact not attaining to the physical or mental growth of which they had the potentiality, and to which they did attain when given an extra daily ration of milk."

Another test which, while not quite so closely controlled as Mann's, extended to large numbers of children, was the British "Milk-in-Schools Scheme." In this also the addition of milk to the hitherto acceptedly normal diets of school children, rated as healthy, resulted in better growth in both height and weight, a higher order of fitness or condition, greater alertness and buoyancy, and an improvement in the average rate of progress in their studies.

School lunches as a means of ensuring at least one good meal a day for every child are being increasingly recognized as a public responsibility.

Among adults, diets better balanced from the viewpoint of the newer knowledge of nutrition have enabled factory employees to work with higher efficiency and less fatigue, increasing both the quality and quantity of their output, with fewer accidents to themselves and their material. Efficiency was also found notably increased in work which involved careful matching of materials.

These are only samples of a large and growing mass of evidence that, even when the starting point is a dietary apparently adequate and a bodily condition already healthy and efficient, we can build to higher levels of health and efficiency by using the guidance of the new knowledge of nutrition in our habitual choice and use of everyday food.

The same material conditions which make the brain of a healthy body a relatively well-protected tissue make it less easy to demonstrate the effect of diet upon mental than upon muscular work. But we have just seen examples in which a more scientific guidance of nutrition resulted in higher mental as well as physical efficiency, even in people who were already healthy and efficient; and the present-day science of nutrition shows that this is logically to be expected.

Our bodies have wonderful self-regulating mechanisms, yet our food does influence our bodily internal environment. Here the blood is the great mediator and the same blood circulates through every part of the body, carrying the influence of the food (whether for better or for worse) to muscles and brain alike.

There seems little reason to doubt and much reason to believe that, whatever one's work may be, the choice of one's daily food is a very large factor in the ability to work at full efficiency and without undue fatigue.

A striking aspect of the nutritional improvement of life is that, with food habits guided by present-day knowledge, full adult capacity and efficiency can be reached at an earlier and held till a later age in the same individual.

So the science of nutrition offers us the opportunity of building health and efficiency to higher levels—even though we were already healthy and efficient. This means both higher attainment and the holding of one's highest capacity for service and for enjoyment of life over a longer time.

Because it had been regarded as an established fact that "longevity depends on heredity," even scientifically trained people have been (perhaps still are) a little slow to assimilate the now fully demonstrated fact that both heredity and nutrition are major factors in determining the length of normal lives.

The extra years which the science of nutrition offers, whether these be estimated at 7 or 10 or more or less, are not to be thought of as added to old age. Rather, they are inserted at the prime, in any life that was not begun too soon to get the full benefit of the newer knowledge. In social-economic terms this means a continuation of the current increase in adult life expectation but with a smaller percentage of years of dependency.

We need not speculate as to whether any individual lives in the future will thereby be rendered superior to the best lives of the past; for there is so large an element of what science still calls chance in inheritance that in particular cases the original chromosomal endowment may dominate the life history. No one doubts that there have been some born geniuses; and no one expects to be able to produce geniuses to order.

What we can and do expect is that, as the new knowledge of nutrition is more generally understood and followed, a greatly increased proportion of people will build their own and their children's lives to those higher levels of health and enjoyment and social usefulness which have hitherto been the privilege of only the most fortunate few.

Correspondingly, we may expect both individual and social enrichment of human life.

Dr. John C. Merriam pointed out how great is the importance of the length of individual lives to the full social use of the knowledge and institutions which mankind has built. And, from the viewpoint of the individual's enjoyment of life, it is now clear that habitual use of the guidance of the science of nutrition can so increase the efficiency and extent of the fully productive years as greatly to improve one's prospect of attaining to life's ideals, whatever these may be.